The raised shorelines at Kingsteps, Nairn.

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Two distinct sets of raised shorelines and associated deposits are present in the region. The older Late Devensian set formed during late-glacial times, that is, from the initial decay of the Main Late Devensian Ice Sheet in this region until the end of the Loch Lomond Stadial (LLS) (Younger Dryas) (Gray and Lowe, 1977). The marine deposits are intimately associated with glacial and glaciofluvial sediments and are backed by discontinuous degraded cliff lines that relate to a series of shoreline remnants lying up to 35 m OD or more around Inverness (Fig. 16, ILG-1 to 10). These shorelines are commonly truncated by the 'Main Postglacial Cliffline', which is almost continuous along the southern coast of the Inverness and Inner Moray firths, and backs the younger, Holocene (Flandrian) set of raised marine deposits and associated shorelines (Fig. 16, IF-1 to 5). This prominent abandoned cliff line was generally thought to have been created by marine erosion during the Holocene, but it is now considered to have been formed mainly in the cold climate of the LLS and that the feature was only trimmed during the mid- Holocene (Sissons, 1981a).

Holocene raised shorelines and deposits are widespread along the southern shore of the Inner Moray Firth, locally concealed beneath dunes of blown sand. They include raised beaches composed of well-sorted shingle, commonly displaying both good clast imbrication and 'herringbone' cross-stratification; silty and sandy deposits are also present, representing deposition in raised tidal flats and brackish lagoons (Fletcher et al, 1996; BGS, 1997). The Holocene deposits were mainly laid down during the 'Main Postglacial Transgression', which culminated between 5.8k and 7.1k years ago in the Inverness area and reached about 8 m above OD at Kingsteps (Cullingford et al., 1991).

The Late Devensian raised shorelines are more fragmentary and relatively less well developed. They are most extensive, extending for a distance of about 5.5 km, landward of the 'Main Postglacial Cliffline' to the east of the village of **Kingsteps** [NH 903 575] (Fig. 42). The regional significance of similar features which are sporadically preserved in the hinterlands of

the Inverness, Inner Moray, Beauly and Cromarty firths was recognized in the pioneering work of Synge (1977a) and Synge and Smith (1980 who recognised the relationship of shoreline features to the broad pattern of late-glacial ice retreat. This work was developed in a series of publications by Firth (1989, 1990a, b), who established the pattern of sea-level changes associated with the deglaciation (Fig. 16). This was achieved by regional correlation of raised shoreline fragments and associated features, such as beach ridges, lying above the 'Main Postglacial Cliffline'. These shorelines were related to ice-front positions identified from ice marginal landforms, such as outwash fans and outwash terraces, which showed ice-front retreat into the heads of the firths (Fig. 17).

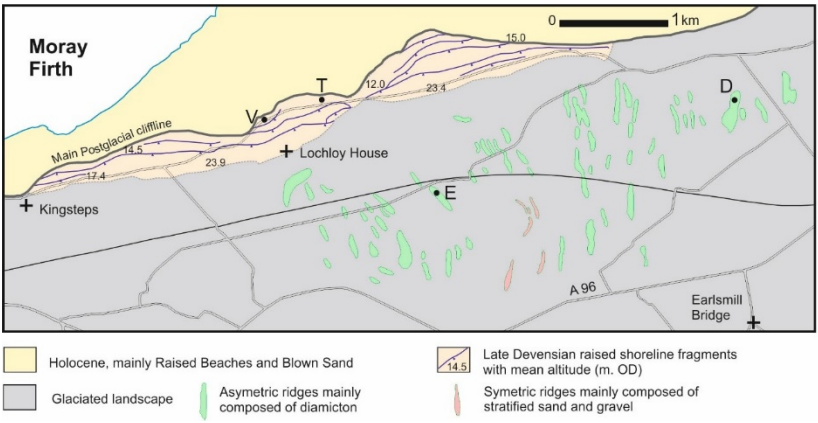

Figure 42. Map showing the staircase of Late Devensian shoreline fragments above the 'Main Postglacial Cliffline' and the distribution of sub-parallel mounds and ridges composed of glacial sediments, east of Kingsteps. (V) viewpoint, (T) trench, (E) Easterton, (D) Downie Hillock.

Up to six Late Devensian shoreline fragments have been identified in the Kingsteps-Lochloy House area. These represent the most complete and extensive staircase of shorelines in the district and have mean altitudes ranging from 12.0 to 23.9 m OD. They are relatively subtle features in the landscape, which could only be mapped by a detailed walk over of the ground and detailed examination of high-resolution stereoscopic aerial photography; the ground surface of whole staircase appears as apparently flat-lying ground on a 5m hill shaded DTM model of the area. These shoreline fragments constitute one of the best and

most important localities that were used in the regional sea-level correlation.

Figure 43. Late Devensian glacial shoreline features near Kingsteps, east of Nairn, looking south-eastwards.

The morphology of the higher shorelines was formerly well displayed around Lochloy House [NH 925 578] (Fig. 43), being readily observable from the viewpoint on the road east of Kingsteps (Fig. 42 V). In recent years, however, some of the more subtle shoreline steps have degraded by ploughing and parts of the landforms are obscured by conifer plantation. Nevertheless, the general form of the landscape is still evident with the shoreline benches rising in elevation towards Lochloy House. The ground continues to rise in elevation inland of the house, which stands on the back feature of the highest shoreline fragment at c. 24m OD. The landscape to the south and east is mainly underlain by till. It continues to rise to over 35 m OD and is characterized by the presence of north-south trending, asymmetric transverse ridges principally composed of diamict, as around **Easterton**. These features are analogous to the 'Dalcross' suite of moraines described by Fletcher et al. (1996). However, the ground to the south-west of Lochloy House, and particularly immediately south of Kingsteps, lies below the height of the uppermost shoreline fragment. This may result from the melting of bodies of stagnant, or buried, ice whilst the highest shorelines were

forming, as suggested by Firth (1990). It may also be due in part to postglacial erosion associated with the present drainage.

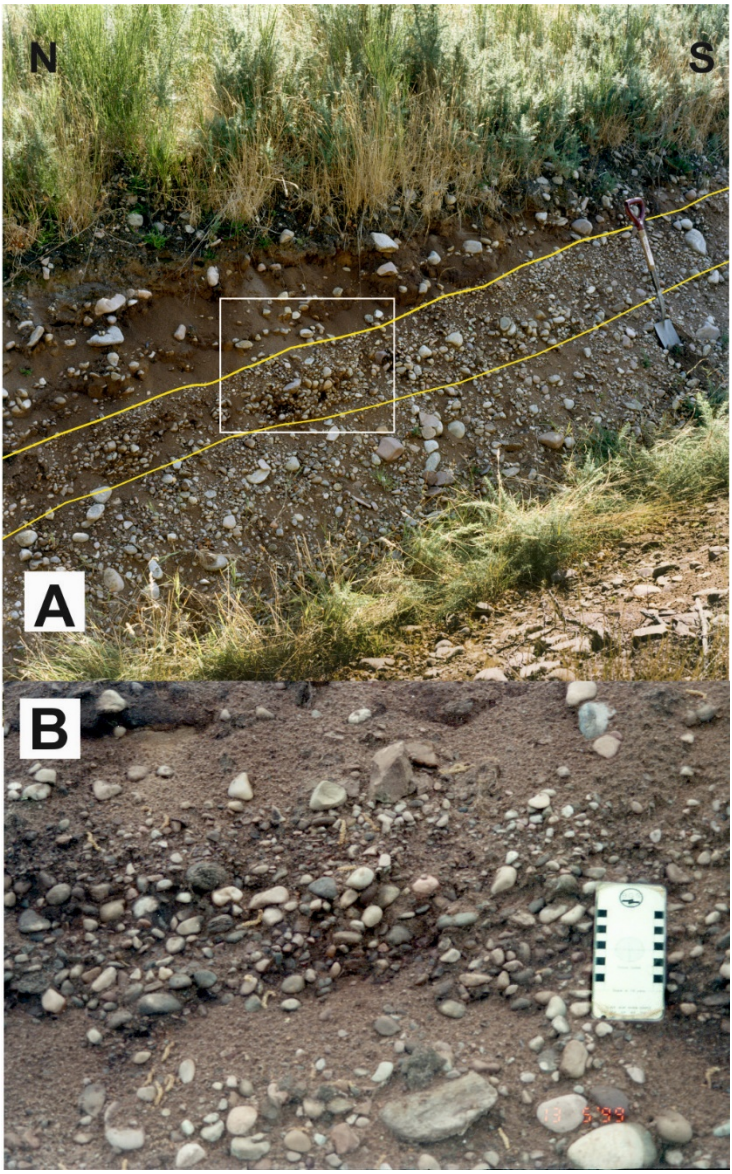

Figure 44. (A) Gently dipping unit of bedded sand and gravel underlying the 12 m shoreline, exposed in a north-south orientated trench section [NH 929 583] in May 1999; spade 0.9 m. (B) Detail of imbrication in open-work shingle.

Exposures in the Late Devensian shoreline deposits are sparse, but a good section in the top 1.5 m of one of the lower shorelines was visible in a 50 m long drainage trench, aligned north to south (Fig. 42 T) at [NH 929 581]. Three sedimentary units were present (Fig. 44 A) all of which thicken and dip at shallow angles towards the sea. The uppermost unit, which reached a maximum thickness 0.6 m, comprised iron-stained, and locally cemented, medium-grained sand with layers of scattered tabular cobbles of metasandstone and brown sandstone. Poorly developed frost wedges, up to 80 **cm** deep, penetrated from the ground surface, through the sand and into the underlying gravel.

The middle unit, typically 0.3 - 0.5 m in thickness, comprised open-work shingle, which was well sorted and contained zones where the clasts were imbricated; in some instances, the imbrication dipped northwards (Fig. 44 B), in others it dipped southwards. The clasts were well rounded and mainly comprised metasandstones, with some granite and sandstone. The paucity of bladed and tabular material mitigates against a strong development of an imbricated clast fabric.

The lowest unit, exposed to a maximum depth of c. 1 m, comprised moderately to poorly sorted gravel, with rounded and subangular cobbles of metasandstone, granite and sandstone in a matrix of medium to fine-grained sand. The unit revealed poorly developed tabular bedding that dipped c. 5^{o} northwards.

The landscape east of Kingsteps is now less impressive than at the time of Firth's work in the 1980's, and when it was surveyed by BGS, in the late 1990's, because of modern ploughing and new forestry obscuring some of the more subtle features. Nevertheless, the site is important as it represents the best-developed and most complete staircase of Late Devensian shorelines in the area. The trench section described in this guide provides a description of the sediments underlying one of the shorelines. It shows evidence of shingle with size and shape sorting and clast imbrication, directed both seawards and landwards, which might be taken as evidence of beach and shoreface processes. Better evidence of former tidal and wave activity takes the form of well-developed 'herring-bone' cross-stratification, as seen in small pits dug into the Holocene

gravelly raised beach deposits nearby and in pit at [NJ 0590 6393], east of the village of Findhorn. This suggests that each of the Late Devensian shorelines formed relatively quickly in comparison to the time taken to form the Holocene raised beaches, or that shoreline processes were dampened during the late-glacial period. The sea merely reworked and winnowed the top of the glacial and glaciofluvial sediments before relative sea level fell and each shoreline was abandoned. The frost wedges observed in the top of the trench section at Kingsteps supports the contention that the late-glacial shorelines formed in a cold climate.